Computation of Effect of Gredients, by Herman Haupt, C. E.

(Read before the American Philosophical Society, Jan. 20, 1871.)

When the maximum load of the same engine on any two different inclinations has been determined by experiment, the data thus furnished will suffice to calculate the load on any other inclination, the load on a level, the angle of friction at which a train will descend by gravity, the tractive power per ton of load required on a level, and the number of pounds adhesion for each ton of load.

Let R = resistance of the train on a level, which is equal to the power of the engine.

W = gross weight of train on a level.

W^1 = Weight of train on grade a.

W^2 = Weight of train on grade b.

It is proper to assume that the power required to move a train and the resistance, which is equal to it, will be in proportion to the gross weight.

The force of gravity on any inclination is in proportion to the height of the plane divided by its length, or as the rise per mile divided by 5280.

The resistance of the train W^1 being in proportion to its weight, will be expressed by $\frac{W^1}{W}R$

and the resistance of W^2 by $\frac{W^2}{W}R$

The gravity of the train W^1 on the grade $a = \frac{W^1a}{5280}$

and of the train W^2 on the grade $b = \frac{W^2b}{5280}$

If the engine is supposed to be loaded to the limit of its capacity on each gradient, then the power exerted must be the same as on a level and

$$\frac{W^1}{W}R + \frac{W^1a}{5280} = R$$

$$\frac{W^2}{W}R + \frac{W^2b}{5280} = R \quad \text{and consequently}$$

$$\frac{W^1}{W}R + \frac{W^1a}{5280} = \frac{W^2}{W}R + \frac{W^2b}{5280}$$

From which the value of R in terms of W W^1 and W^2 is found.

$$R = W\frac{W^2b - W^1a}{5280\ (W^1 - W^2)}$$

Take now the former equation $R = \frac{W^1}{W}R + \frac{W^1a}{5280}$

from which a second value of R is obtained $= \frac{W\ W^1a}{5280\ (W - W^1)}$

Placing these two values of R equal to each other, there results $\frac{W^1a}{W-W^1} = \frac{W^2b-W^1a}{W^1-W^2}$

By substituting in the equation the values of W^1 W^2 a and b, as determined by observation, the values of W, or the gross load on a level can be ascertained.

By substituting the values of W W^1 W^2 a and b, the value of R on the power exerted by the engine is obtained.

By dividing this power in pounds by the gross load on a level, the tractile power per ton is determined.

As the power of an engine is always sufficient to slip the wheels on a dry rail, the adhesion is equal to the actual power exerted in moving the train and divided by the weight on drives, gives the proportion between adhesion and weight.

The angle of friction can be found when the tractive power per ton of of 2000 lbs. on a level (T) has been determined, by the equation.

Angle of friction expressed in feet per mile = $\frac{T \times 5280}{2000}$

It has been customary for engineers to consider the angle of friction as 16 to 18 feet per mile, the tractive power per ton on a level 8 pounds, and the adhesion one-eighth the weight upon the drives; but to obtain reliable data from the actual operation of roads running full trains, a letter was addressed to A. J. Cassatt, Gen'l Sup't of the Penna. R. R., who furnished the following data:

A standard 10 wheel freight engine with 3 pairs of 4½ feet drivers with average water and coal, weighs	75,500 lbs.
Weight on drivers,	53,000 "
Weight of tender with coal and water,	50,000 "
Such an engine will haul on a moderately straight and level road 50 loaded cars of 40,000 lbs. each. Gross load,	1062 tons.
On a grade of 10 feet to the mile, 43 cars,	922 "
" " 26 " " " 35 "	762 "
" " $52\frac{8}{10}$ " " 17 "	402 "
" " 96 " " " 11 "	282 "

And the engine would work easier with 50 cars on the level than in either of the other cases and with most difficulty in the last.

Herman J. Lombaert, Esq., Vice President and former General Superintendent of Penna. R. R., gives as a full average load for actual work in the usual conditions of the rail.

	Tons.
Load on $52\frac{8}{10}$ ft. grade, 16 cars. Gross load of engine,	382
" " 10 " " 40 " " " "	862

As it is proper to allow a margin for unfavorable condition of rails, the calculations will be made on the data furnished by H. J. Lombaert.

Substituting the values of a b W^1 W^2, which are 10, $52\frac{8}{10}$, 382 and 862, the value of W, or the gross load on a level is found be 1210 tons.

The value of R or the tractive power on a level, is 11,160 lbs., or $9\frac{2}{10}$ lbs. per ton.

The angle of friction is $\frac{9.2 \times 5280}{2000} = 24.28$ feet per mile.

The adhesion is $\frac{11,160}{53,000}$ or nearly one-fifth of weight on drives.

From the data thus obtained a simple formula may be found to determine the load of the engine on any given inclination, a.

Let P = tractile power of engine on a level = 11,160 lbs.

a = feet per mile of inclination.

W^1 = weight of train on incline a, including engine and tender.

Then $W^1 \times 9.2$ = power required to move W^1 on level.

And $W^1 \frac{a}{5280}$ = gravity on incline a, in tons or $W^1 \frac{2000}{5280}$ a, in pounds.

$$9.2\, W^1 + \frac{2000}{5280} W^1 a = \text{power of engine} = 11,160 \text{ lbs.}$$

$$\text{Or } W^1 = \frac{11,160}{9.2 + .38a}$$

If a be supposed equal to 48.56, or twice the angle of friction, the load would be 404 tons nearly, or one-third the load on a level.

On a grade of 30 feet the load would be 541 tons. The grade that would require double the power of a grade of 30 feet would be 84½ feet.

If the gross load of a train on a grade of 30 feet be 541 tons, the engine and tender being 63 tons, the cars and contents will weigh 478 tons, or if 18,000 lbs. be allowed for each car and 22,000 lbs. for load, the number of cars will be 27 and the net load 297 tons, weight of cars 243 tons.

If the return cars shall be only one-fourth loaded, which is probably a full proportion for the Shenadoah Valley extension, the gross weight of the trains would be 380 tons.

The inclination that would employ the full power of the engine in hauling 380 tons, would be 53 feet.

The inclination that would employ the full power of an assistant engine in hauling a gross load of 380 tons, would be 130 feet, but allowance must be made for the weight of the assistant engine.

The following description of Indian sculpture on the banks of the Monongahela River, by Jos. D. Reid, was received through Prof. Cope, accompanied by a drawing of the same.

Sketch and Description of a Carved Rock *on the bank of the Monongahela River, Pa.*, by Joseph D. Reid.

(*Read before the American Philosophical Society*, Jan. 20, 1871.)

The engraving represents the face of a large rock lying on the east bluff of the Monongahela River, in Fayette County, Pennsylvania, opposite the village of Millsborough and the mouth of Ten Mile Creek.